



Multi-scale wake modelling - Wind farm and cluster scale interaction

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Multi-scale wake modelling

Wind farm and cluster wake interaction



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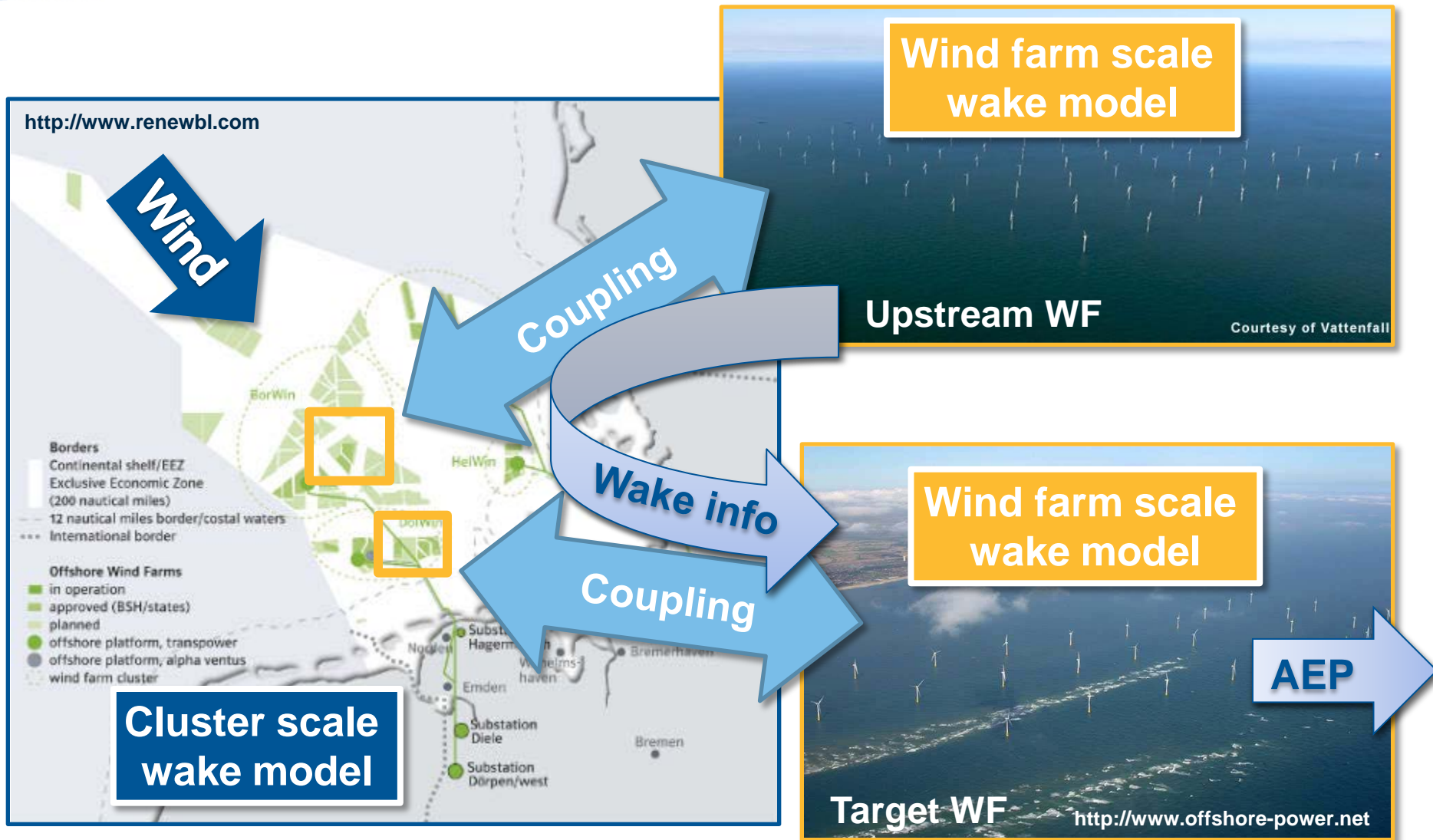
Support by



- Vision
- Wind Farm Scale Wake Modelling
- Cluster Scale Wake Modelling
- Coupling Wind Farm and Cluster Scale
- Summary

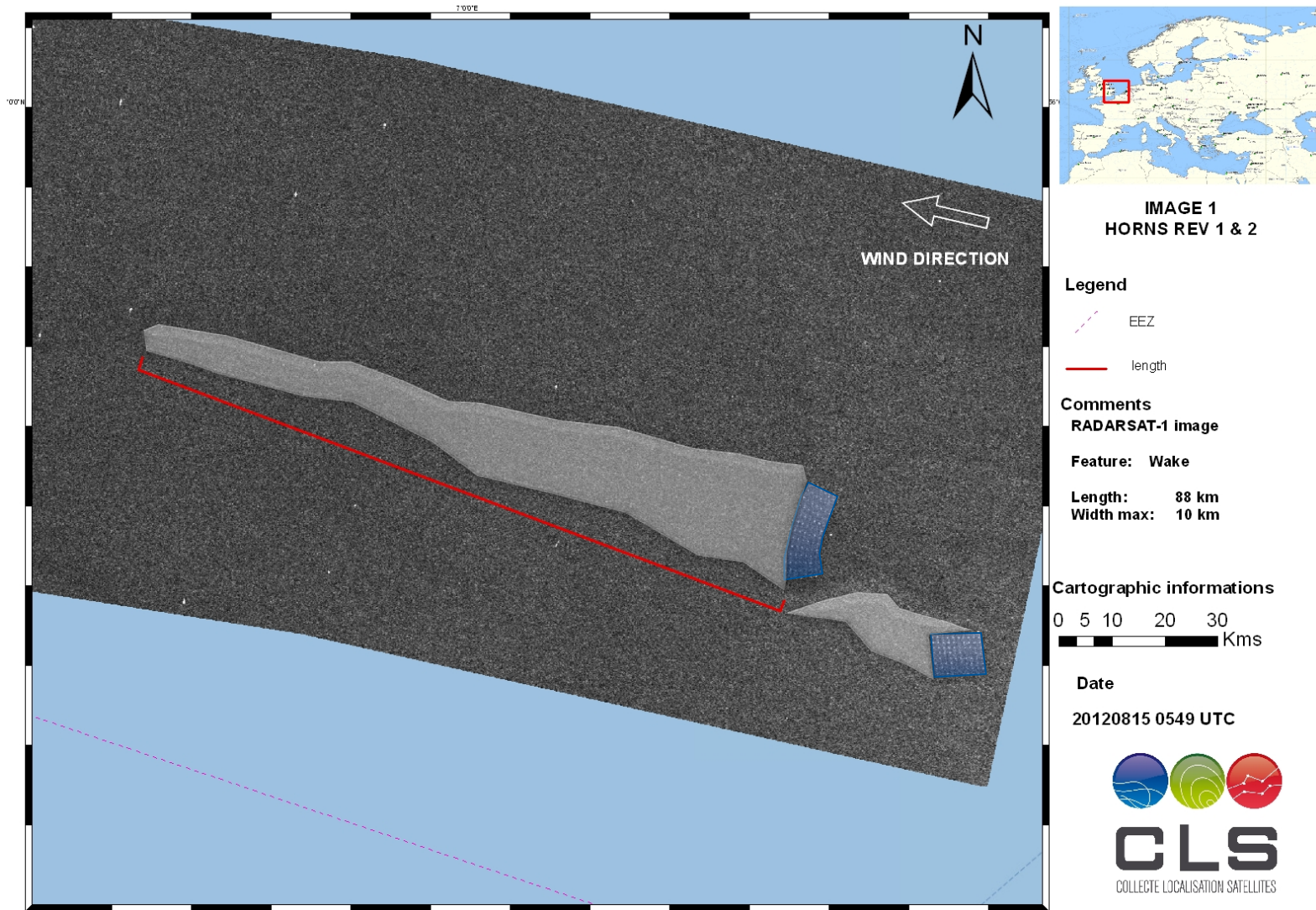
Introduction

The “big wake” picture



The Challenge

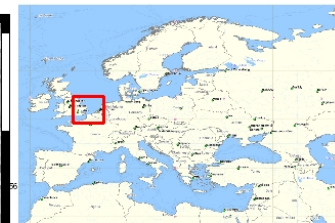
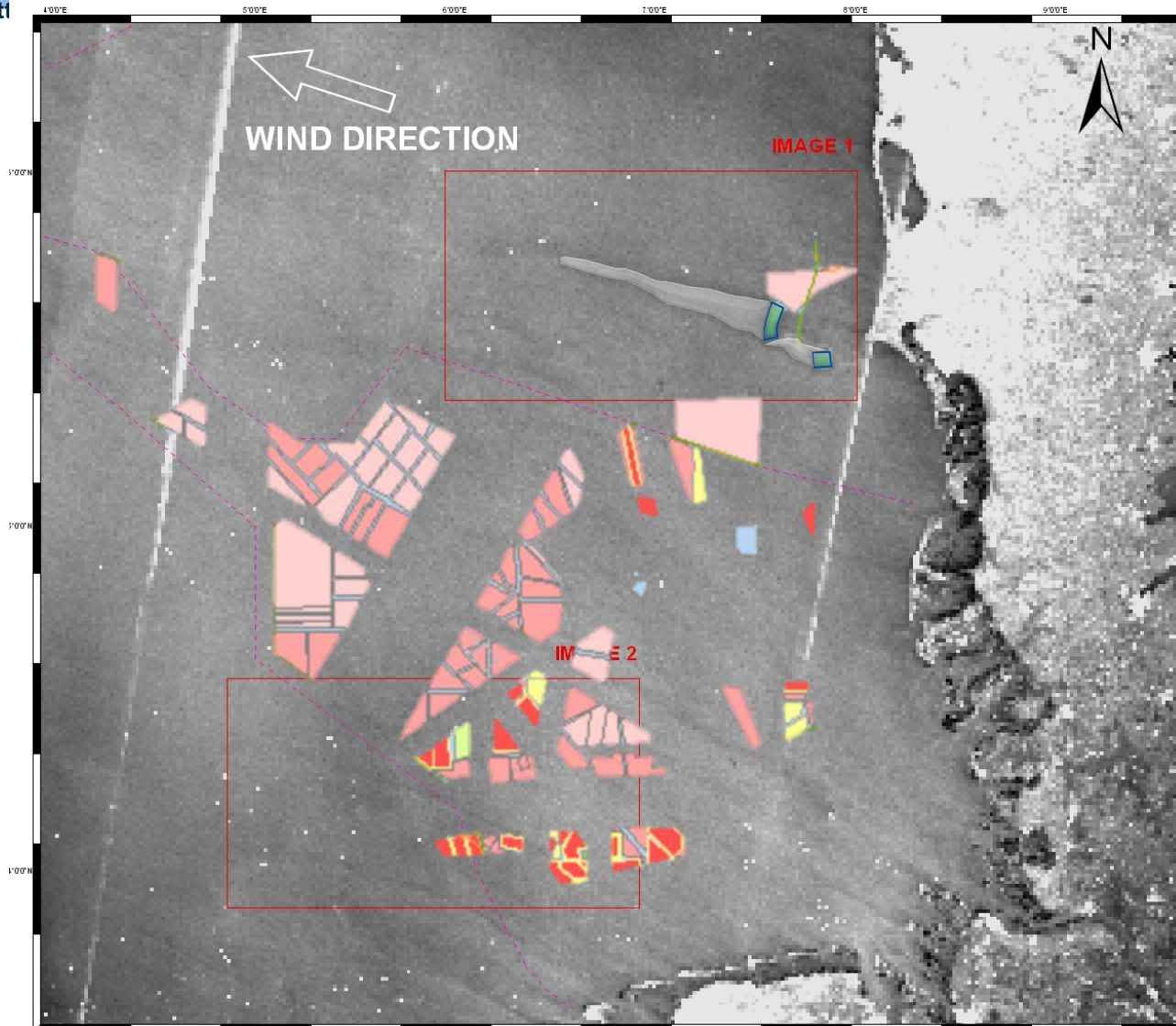
Cluster scale wake satellite pictures



The Challenge

Cluster scale wake satellite pictures

htf



NORTH SEA

Legend

- EEZ
- area of interest

Comments

RADARSAT-1 image

Cartographic informations

0 20 40 80 120 Kms

Date

20120815 0549 UTC

*“Identify, benchmark, provide **guidelines** for and couple the **existing wake models** that can operate over **wind farm scale** and **cluster scale**.”*

Wind farm scale wake models



DWM



WASP/NO
J

U.PORTO

RANS



CRES
flowNS



Ainslie



FarmFlow

FUGA

GCL

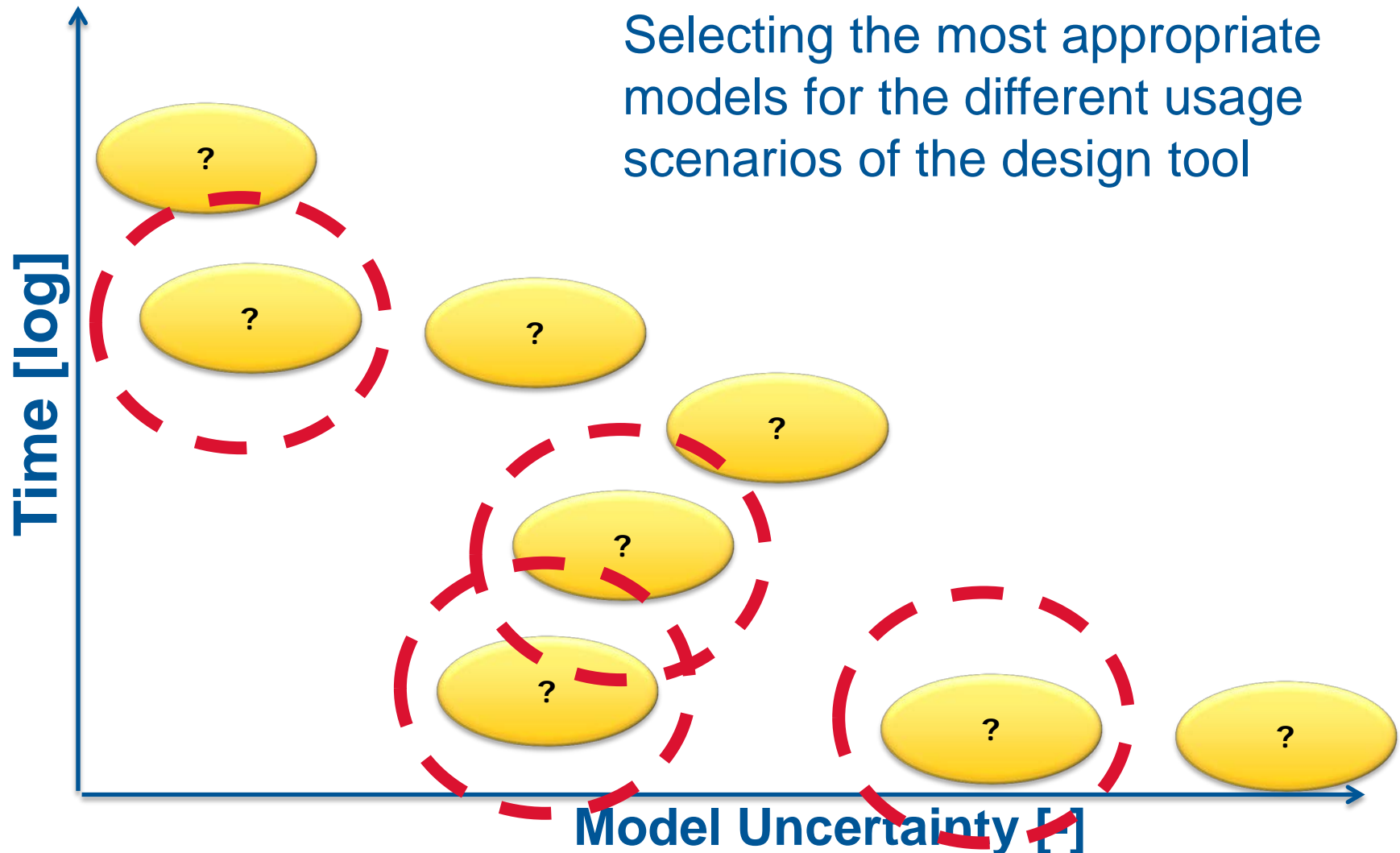
NOJ

Engineering

Simplified
CFD

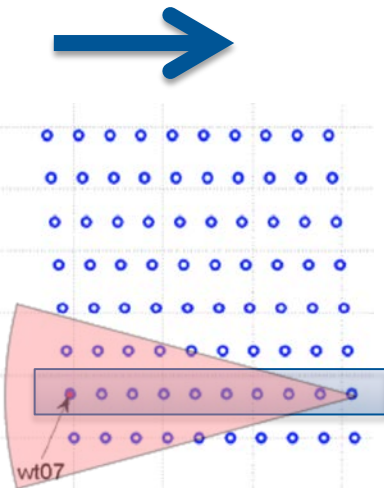
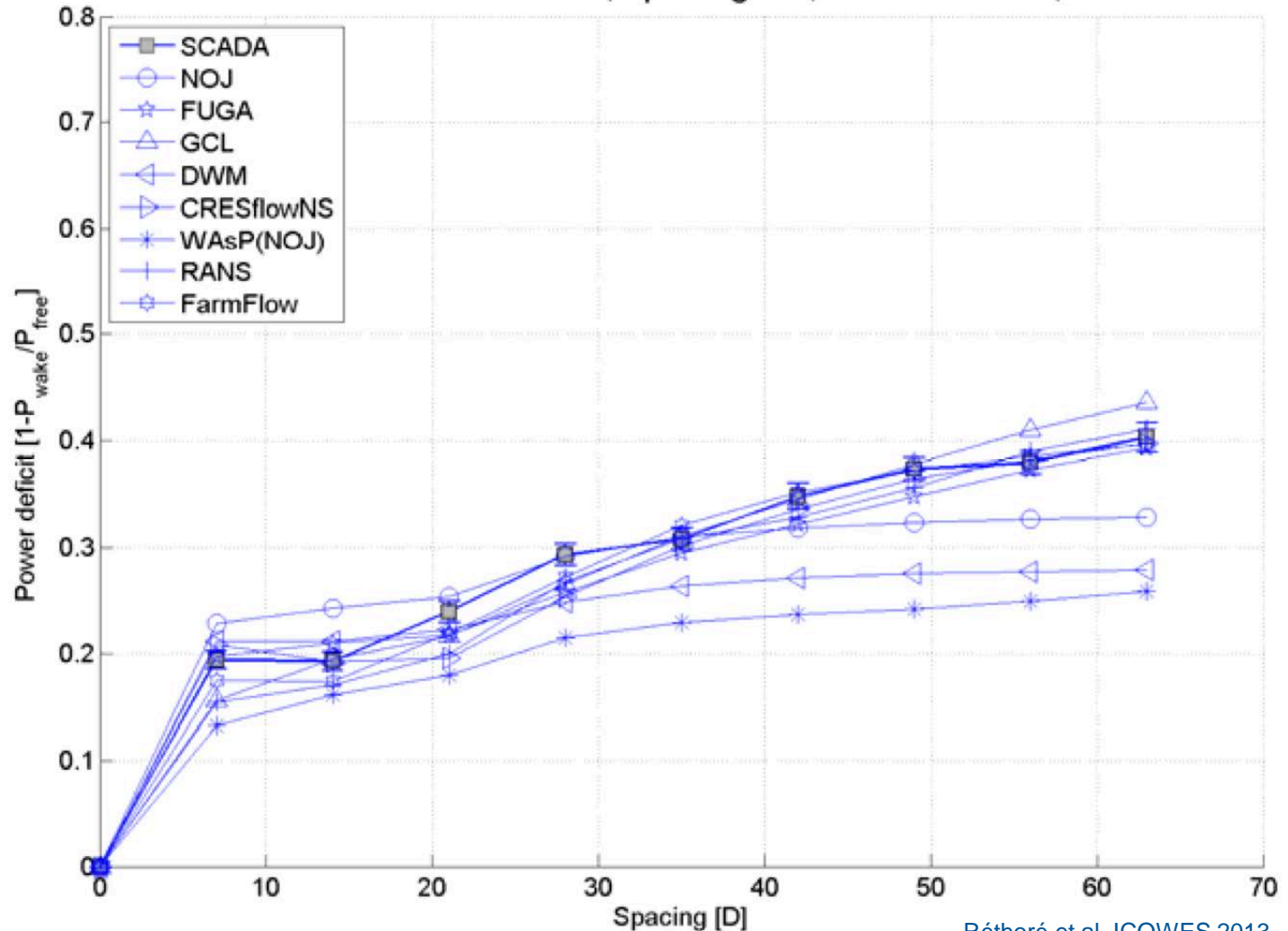
Full CFD

Benchmarking purpose



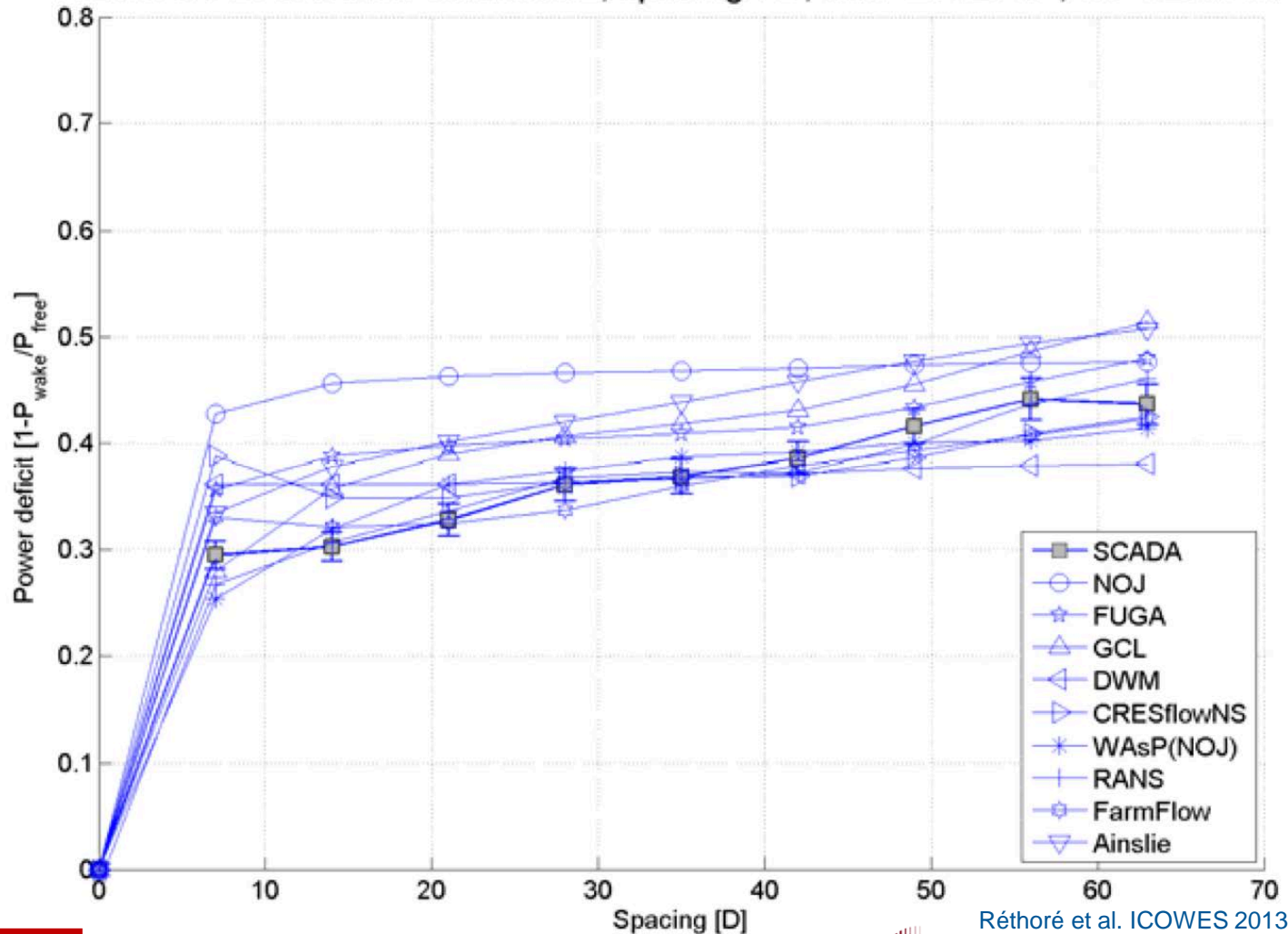
Benchmark preliminary results: Power deficit along a line of turbines

HornsRev-270Neutral-validation3; spacing 7D; wdir=270±15°; ws=8±0.5 m/s



Benchmark preliminary results: Power deficit along a line of turbines

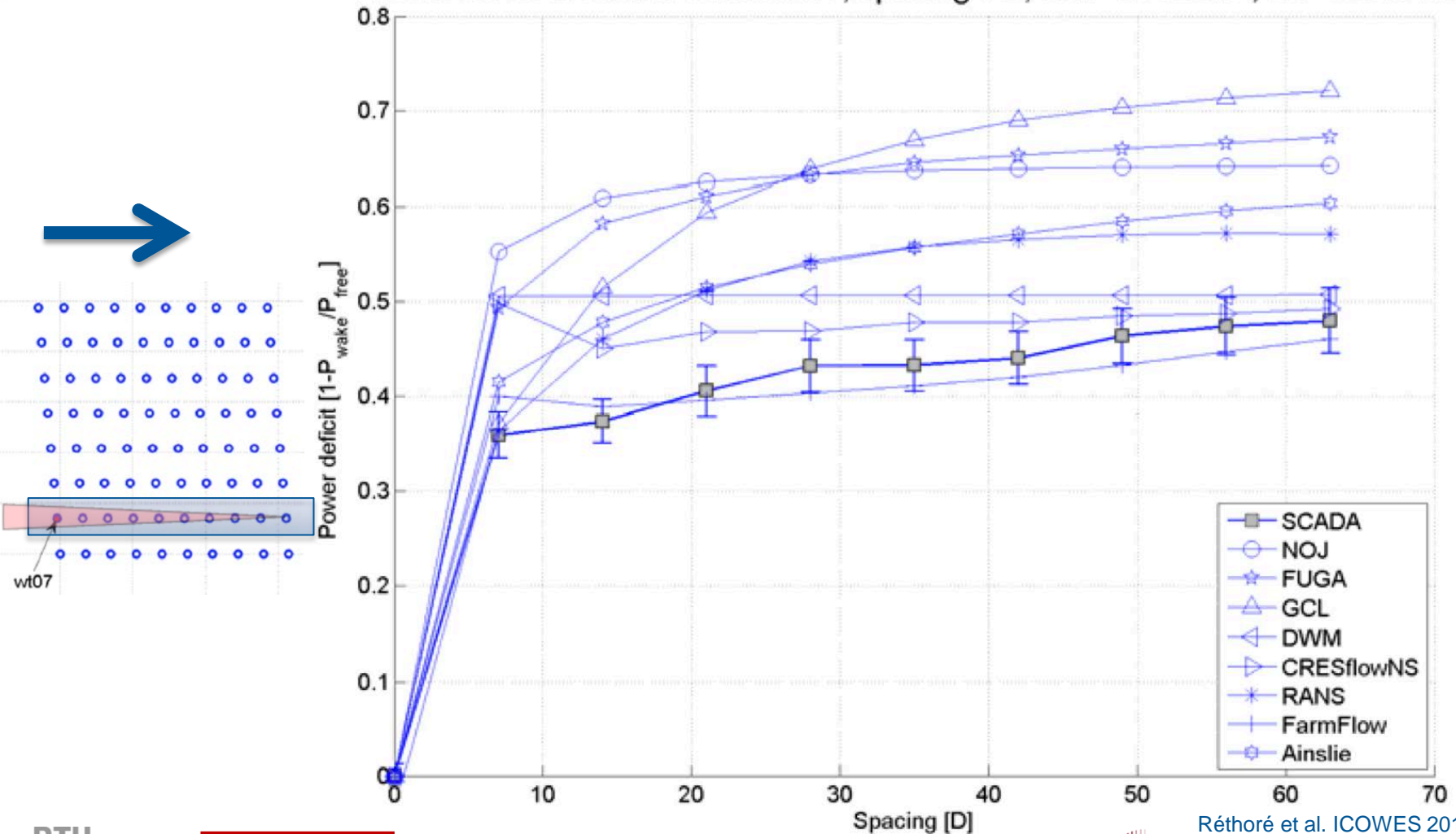
HornsRev-270Neutral-validation2; spacing 7D; wdir=270±7.5°; ws=8±0.5 m/s



Réthoré et al. ICOWES 2013

Benchmark preliminary results: Power deficit along a line of turbines

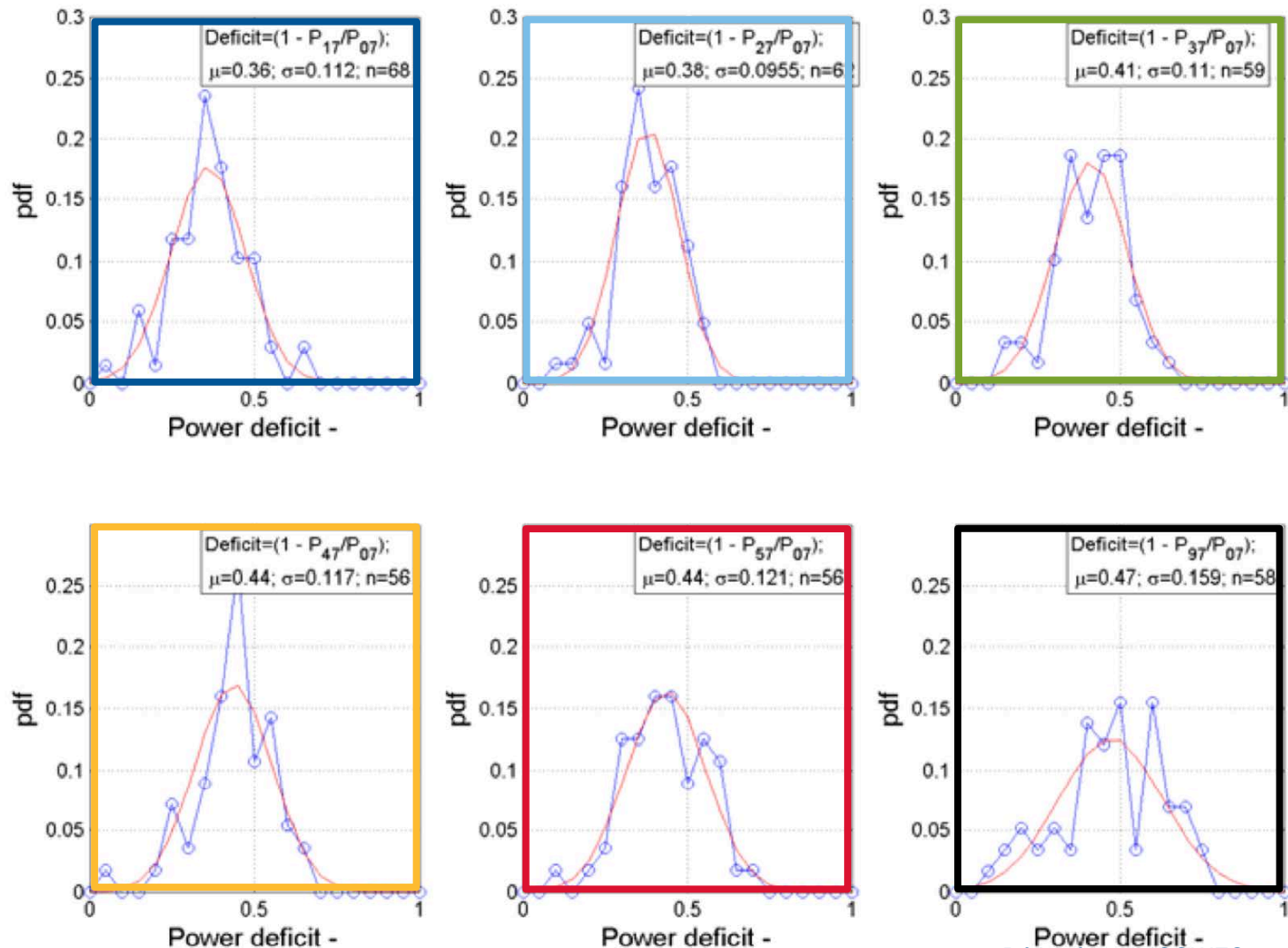
HornsRev-270Neutral-validation1; spacing 7D; wdir=270±2.5°; ws=8±0.5 m/s



Réthoré et al. ICOWES 2013

Challenge: Very noisy datasets!

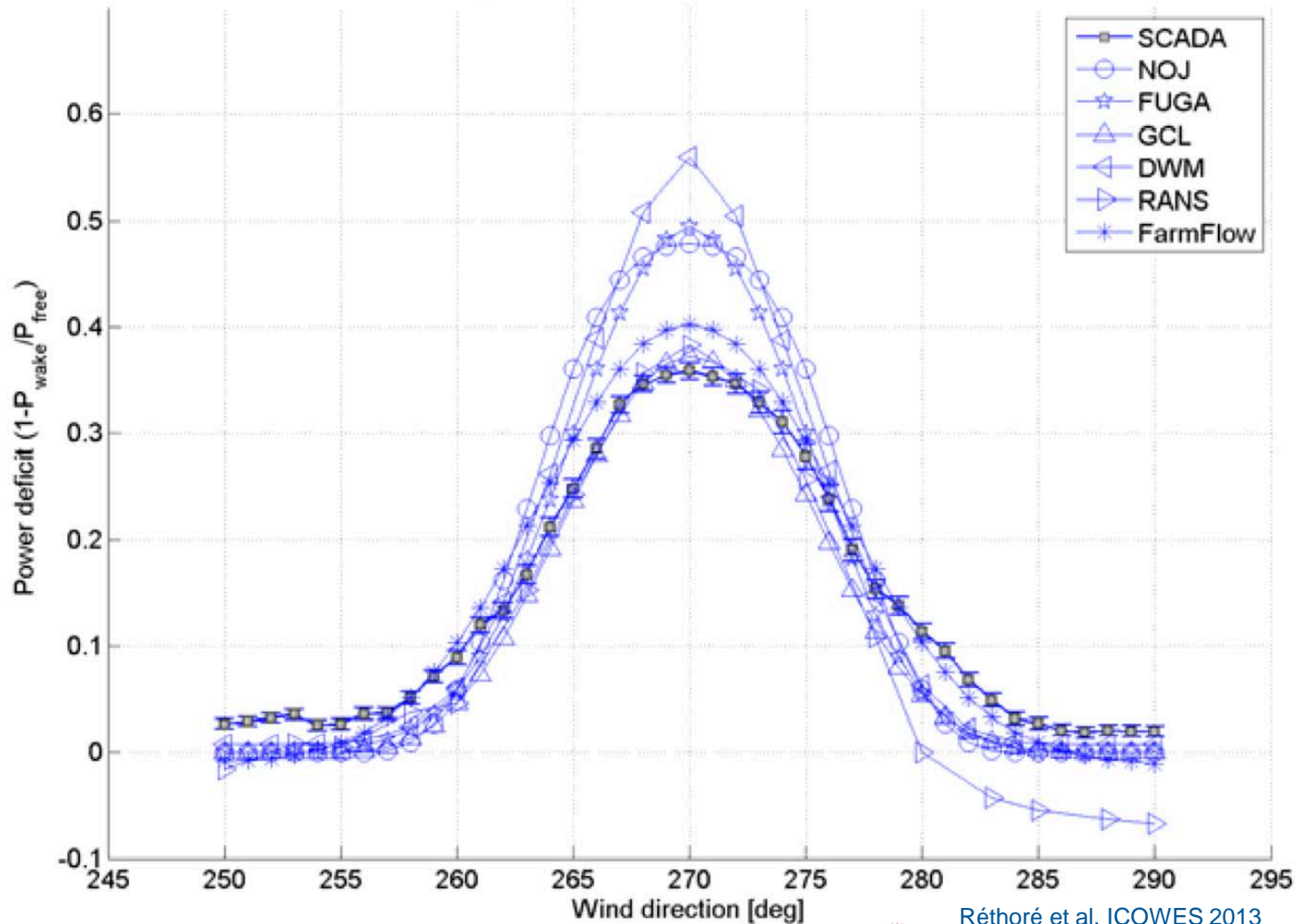
Horns Rev: Power deficit; $V=8\pm 8\text{m/s}$; $\text{WDIR}=270\pm 2.5^\circ$; row 7



Benchmark preliminary results:

Power deficit distribution vs wind direction

HornsRev-270dist; spacing 7D; wdir=270±20°; $\Delta=5^\circ$; ws=8±0.5 m/s



Réthoré et al. ICOWES 2013

Cluster Scale Wake Model



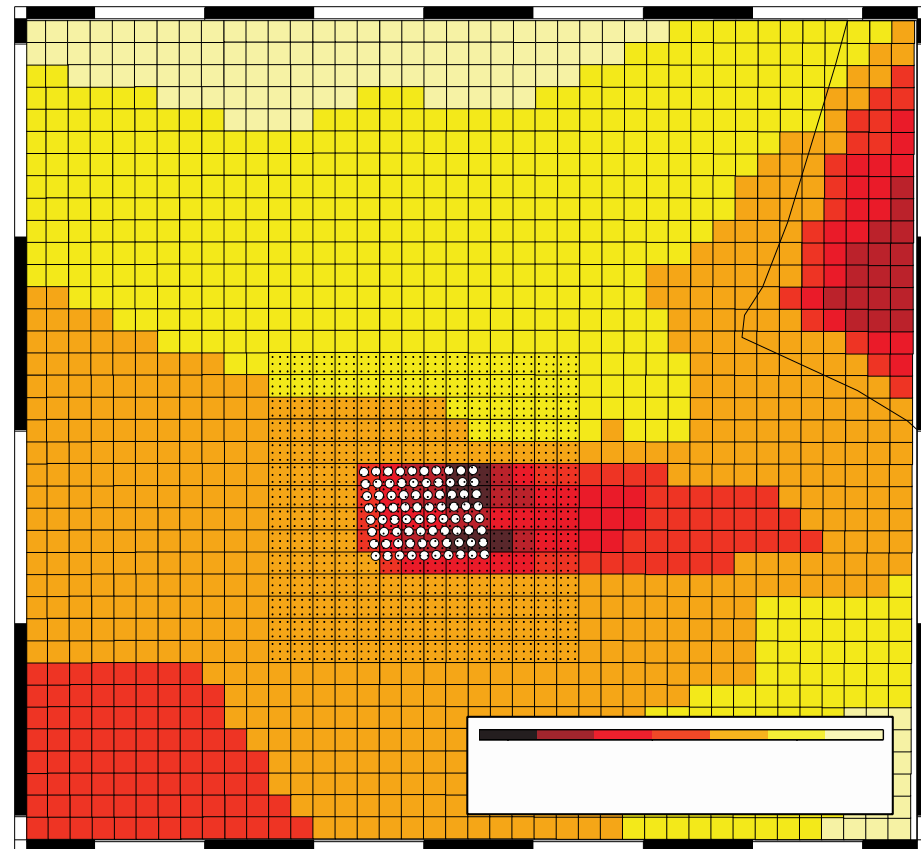
WRF

WRF

WRF

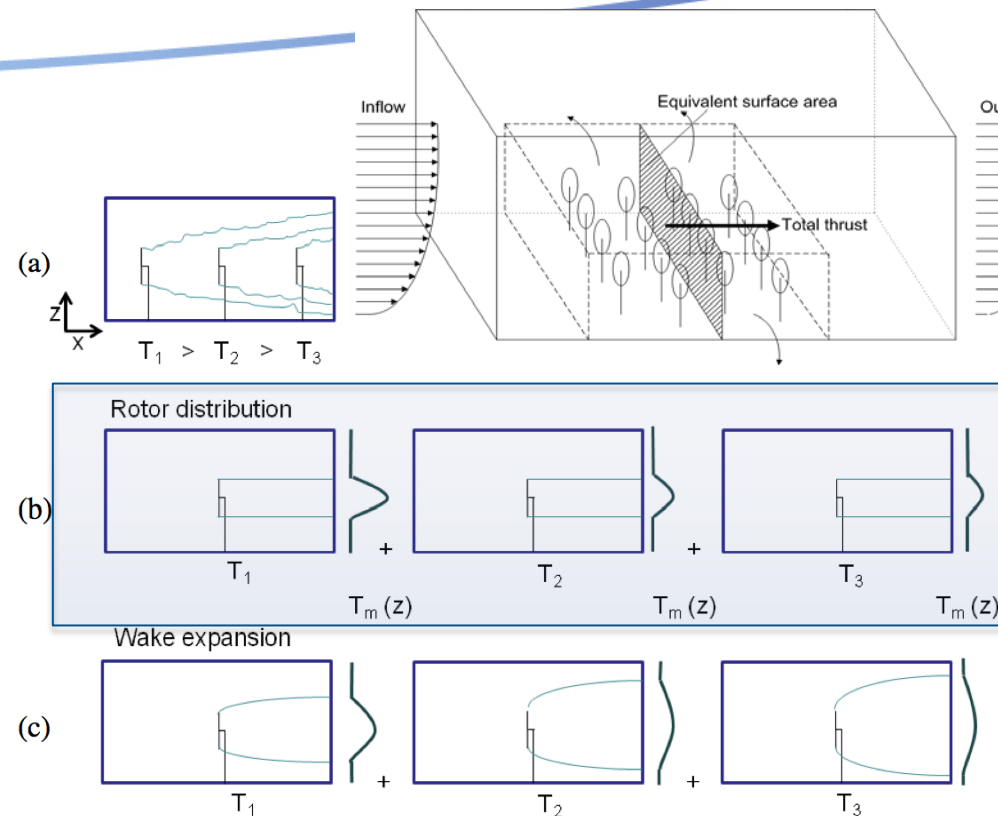
Different mesoscale wake modelling strategies

- Should we run the mesoscale model dynamically or in a pseudo-steady state way?
⇒ Compromise between computational expense and physical complexity
- How fine can be the meso-grid cells?
⇒ Finer cells let each wind turbine have its own cell, but approach the limit of model accuracy
- How should the turbine force be applied in the domains?
 - Thrust force
 - Added Roughness



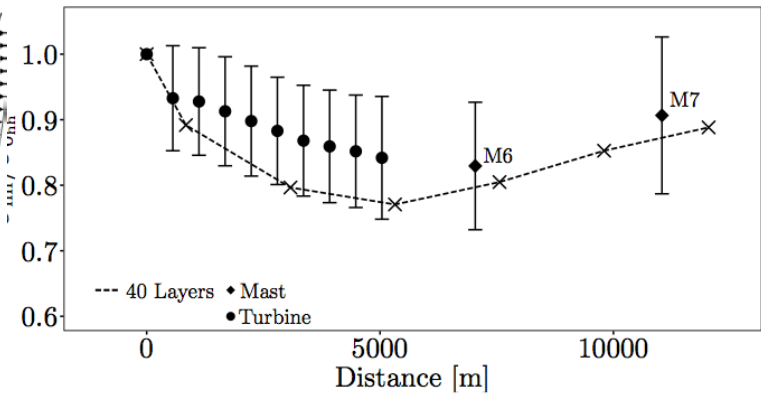
Jimenez et al. Wind Energy (under review)

Windfarm scale => Cluster scale

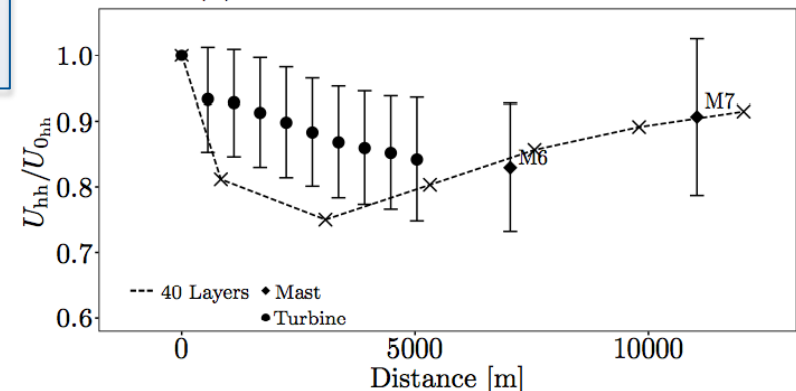


Badger et al. ICOWES 2013

(c) WRF-CRES-ROTOR



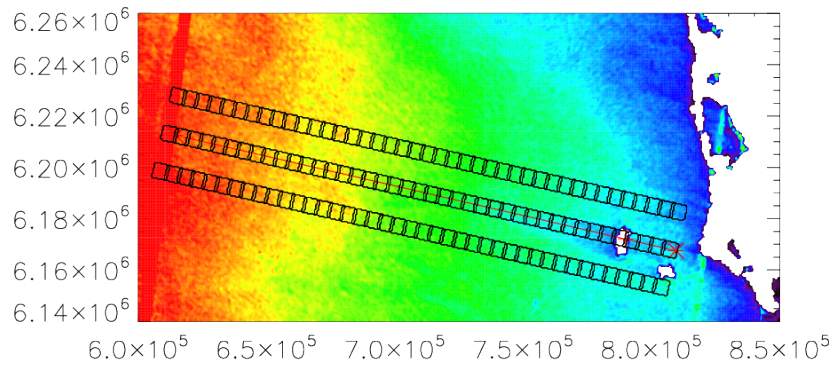
(d) WRF-CRES-ROTOR-FA



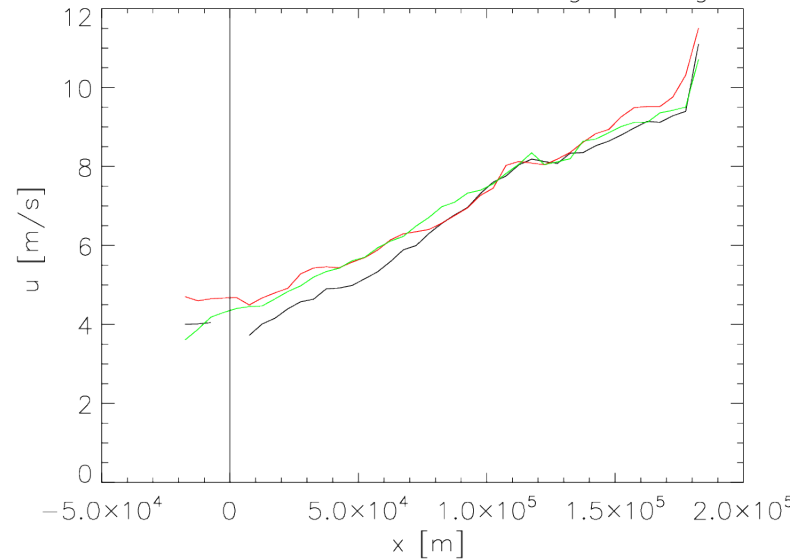
Parameterization	thrust calculation	vertical thrust distribution	aggregation
WRF-EWP	turbine thrust curve	diffusive wake expansion	meso grid aggr.
WRF-CRES-EWP	CRES	diffusive wake expansion	meso grid aggr.
WRF-CRES-ROTOR	CRES	proportional to rotor swept area per level	meso grid aggr.
WRF-CRES-ROTOR-FA	CRES	proportional to rotor swept area per level	wind farm aggr.

SAR scene analysis

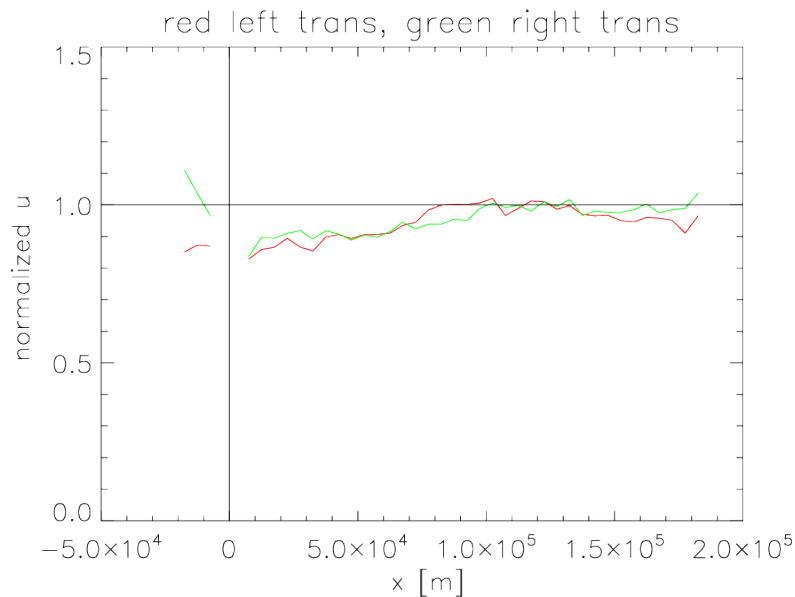
Longitudinal transects



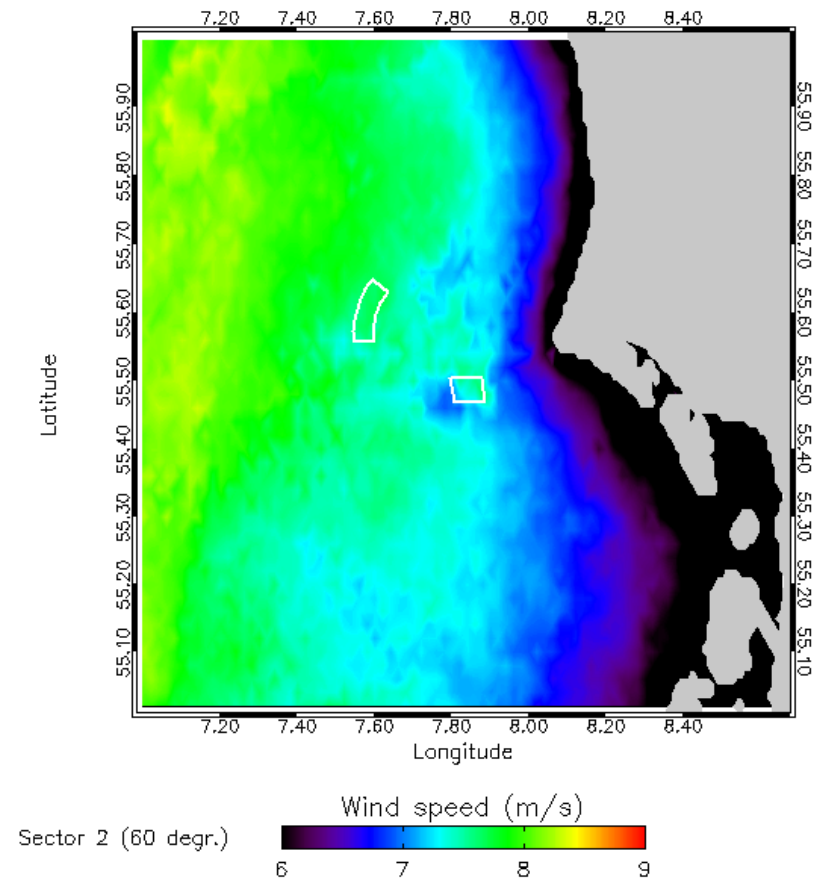
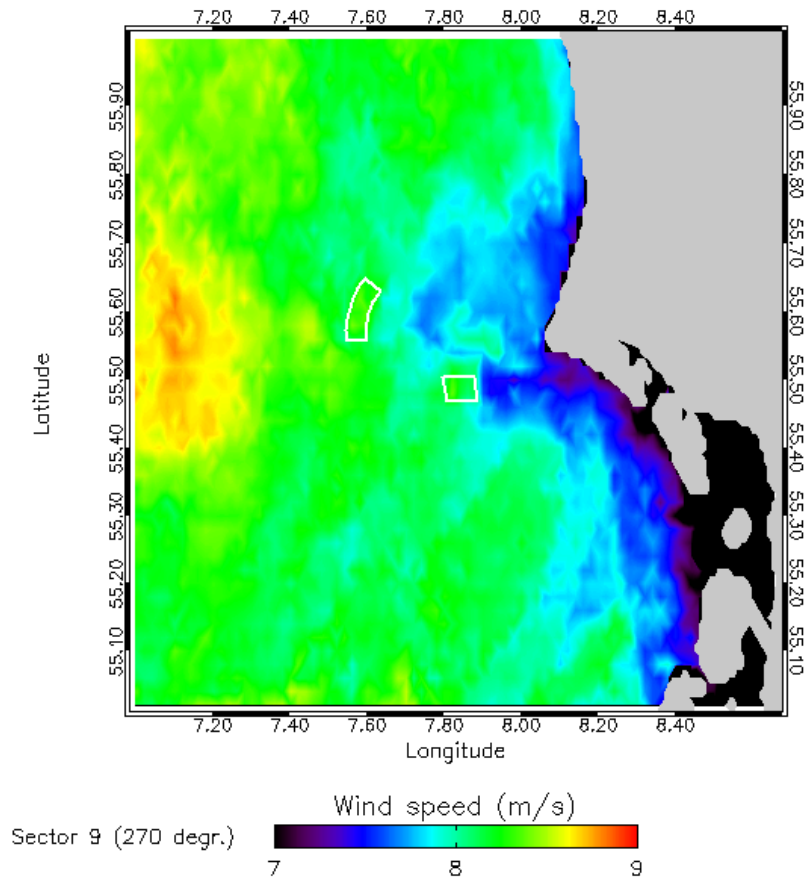
main centre trans, red left trans, green right trans



Deficit for ~80 km



SAR derived mean wind climate around wind farms many scenes



- Different types of data sets:
 - SCADA data
 - Satellite pictures
 - Long range LIDAR + ship mounted LIDAR
- Challenges:
 - Limited amount of datasets
 - No twin wind farm dataset available
 - New area of research

Summary

- Challenging and exciting area of research
- Complex models to setup and expensive to run
- Broad area of expertise focused on solving an important problem:
 - Wake Modelling
 - Mesoscale
 - LIDAR
 - Satellite
 - Wind farm data analysis
 - Industry end users



Thank you very much for your attention



Support by

